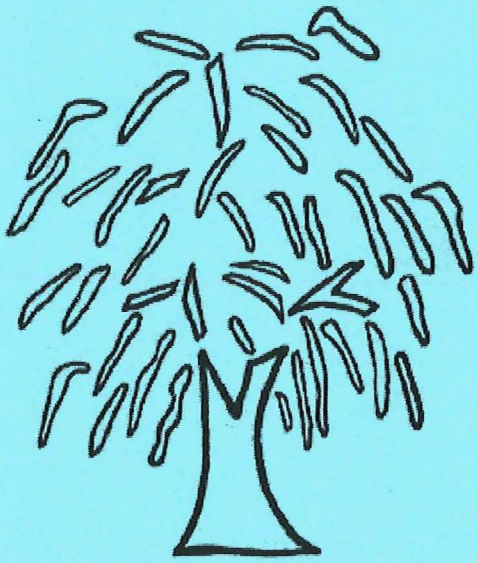
Forest Health Conditions in Wisconsin



Annual Report 2001

Compiled and Edited by
Division of Forestry
Forest Health Protection Staff
Wisconsin Department of Natural Resources
PO Box 7921
Madison, WI 53707

WISCONSIN
DEPT. OF NATURAL RESOURCES

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Forest Protection

Todd Lanigan
Forest Pest Specialist:
West Central region
Eau Claire 715-839-1632
Todd.Lanigan@dnr.state.wi.us

Shane Weber
Forest Entomologist:
Northern region
Spooner 715-635-4156
Shane.Weber@dnr.state.wi.us

John Kyhl
Forest Entomologist
Gypsy Moth Specialist Coordinator:
Southeast
Milwaukee 608-275-3275
John.Kyhl@dnr.state.wi.us

Bill McNee
Gypsy Moth Specialist Coordinator:
Statewide
Green Bay 920-492-5930
Bill.McNee@dnr.state.wi.us

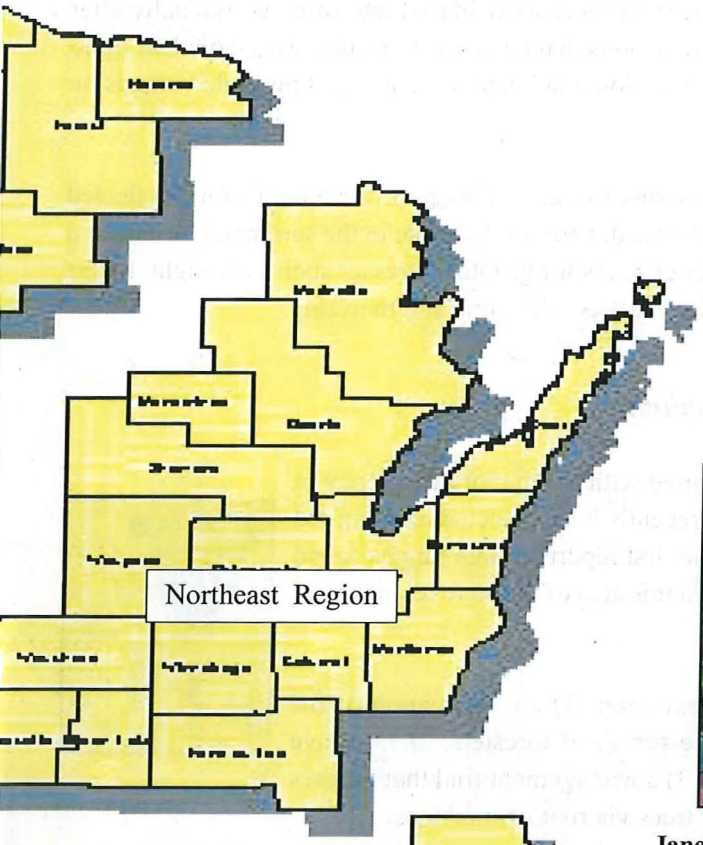
Mark Guthmiller
Gypsy Moth Specialist Coordinator and
Forest Health Technician: **Statewide**
Madison 608-275-3223
Mark.Guthmiller@dnr.state.wi.us

Health Staff

Kyoko Scanlon
Pest Specialist:
Northern region
Rhinelander 715-365-8934
Kyoko.Scanlon@dnr.state.wi.us

Linda Williams
Forest Health Specialist:
Northeast region
Green Bay 920-492-5872
Linda.Williams@dnr.state.wi.us

Sally Dahir
Forest Health Technician
Statewide
Madison
608-275-3319
Sally.Dahir@dnr.state.wi.us



Jane Cummings Carlson
Forest Pathologist
Statewide
Madison 608-275-3273
Jane.Cummings-Carlson@dnr.state.wi.us

Andrea Diss
Gypsy Moth Coordinator
Statewide
Madison
608-264-9247
Andrea.Diss@dnr.state.wi.us

Alerts

Actinopelte Leaf Spot

and other potential unknown causes of late summer necrosis of bur and white oak leaves

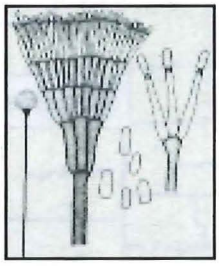
— In late July, bur and white oaks scattered throughout western and southwestern Wisconsin showed the following symptoms:

- Leaves with **water-soaked lesions**, eventually turning brown, on the distal portion of the leaf.
- **Brown or curled leaves** most common in the lower crown
- **Whole crowns** with brown and curled leaves

These symptoms have been observed over the past several years yet they appear to be more widespread this year. Affected leaves are heavily infected with a leaf spot fungus called *Actinopelte dryina*; common name, Actinopelte leaf spot. The symptoms show in mid-late summer, typically after the hottest part of the summer. The fungus causes small brown lesions that coalesce and cause the whole leaf tip to turn brown. The disease also causes **small cankers** on the twigs. Some infected trees also had multiple wounds on the twigs from periodical cicada and tree hopper activity.

There may be other factors involved including other insects and diseases as well as environmental factors. Selected infected trees will be closely observed in 2002. Since infected trees did not refoliate late in the summer, nutrient and sugar reserves were not stressed and trees are expected to leaf out next spring. Other stresses such as drought, tatters and defoliation by the gypsy moth are expected to increase the chances of decline and mortality.

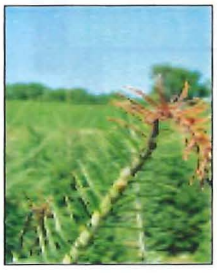
Leptographium



—A root disease fungus, ***Leptographium*** spp., has been reported with much more frequency in southern and western Wisconsin in the last 10 years, and has recently been detected in dying red pines in Oneida and Florence counties, as well. These are the first reports of this fungus found in northern Wisconsin and its role in red pine pocket decline in this area of the state has not been studied.

Three areas of investigation will be initiated within the next year: 1) an evaluation of the incidence and severity of pocket decline through a statewide survey of foresters, 2) extensive site evaluation of locations revealed through the survey and, 3) a management trial that focuses on limiting the underground spread of the fungus to healthy trees via root connections.

Sclerophoma Shoot Blight



—A shoot blight on balsam and concolor fir has been tentatively identified as being caused by Sclerophoma (teleomorph) *Delphinella abietis*. Symptoms include curling and necrosis of newly developing shoots in early summer. This condition has been observed in two Christmas tree plantations; one in Dane County, one in Waushara County. After affected shoots turn brown, they dry up and fall off. Additional samples will be collected in 2002 to confirm the identity of the fungus.

The Resource

Proportion of Forest Land and Timberland

The area of forestland in Wisconsin has been steadily increasing in recent decades and currently stands at almost 16.0 million acres, representing 46% of the total land area. The state now has the most forest land it has ever had at any time since the first forest inventory in 1936. Wisconsin's forests are predominately hardwoods, with 84% of the total timberland area classified as hardwood forest types. The primary hardwood forest type in the state is maple-basswood (Figure 1), which makes up 5.3 million acres (34%) of Wisconsin's timberland area. Conifer types represent 16% of the total timberland area (pine forests - 8%, spruce-fir - 6%, and swamp conifers - 2%).

Wisconsin timberland increased by 940,000 acres between 1983 and 1996.

- 1968 - 14.54 million acres
- 1983 - 14.76 million acres
- 1996 - 15.70 million acres

Timberland is defined as forest land that is producing, or is capable of producing, more than 20 cubic feet per acre per year of industrial wood crops under natural conditions, that is not withdrawn from timber utilization, and that is not associated with urban or rural development.

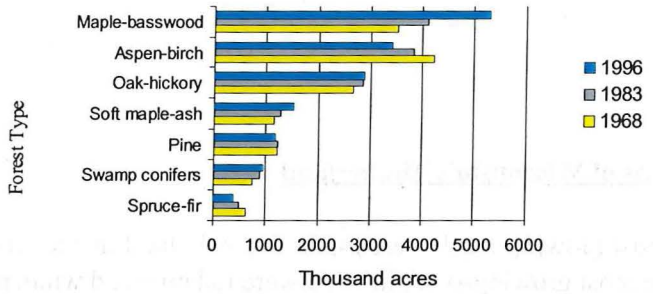


Figure 1. Area of timberland (in thousand acres) by forest type for 1983 and 1996. Data taken from 1996 FIA survey.

Ownership of Wisconsin's Timberland

Individual private landowners are the largest group of timberland owners in Wisconsin, owning 57% of all timberland in 1996 (Figure 2). counties and municipalities are the largest group of public owners, holding 15% of the total area of timberland in Wisconsin. The percentages of ownership have remained relatively constant since the forest inventory in 1956.

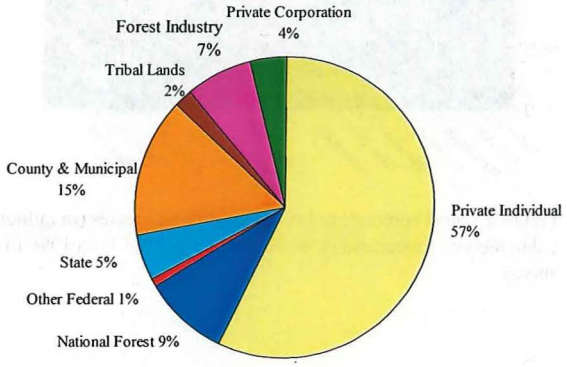


Figure 2. Ownership of Wisconsin's forests. Data taken from 1996 FIA survey.

Growing-stock Volume of Wisconsin's Timberland

Growing-stock volume on timberland in Wisconsin increased from 16.5 billion cubic feet in 1983 to 18.5 billion cubic feet in 1996 (Figure 3), reflecting an increase in both area and stocking during the 13 years between inventories. In both 1983 and 1996, hardwoods accounted for $^3/_4$ of all growing-stock volume.

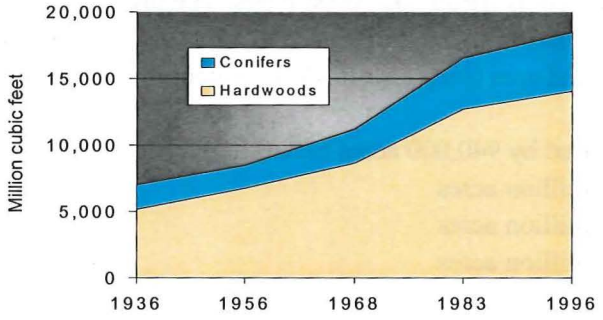


Figure 3. Growing stock volume (in million cubic feet) on timberland in Wisconsin, 1936-1996. Data taken from 1996 FIA survey.

Most Common Species Groups of Wisconsin's Timberland

The species groups with the most growing-stock were aspen, red oak, hard maple, and soft maple (Figure 4). The conifer species groups with the most growing-stock in 1996 were red pine and white pine.

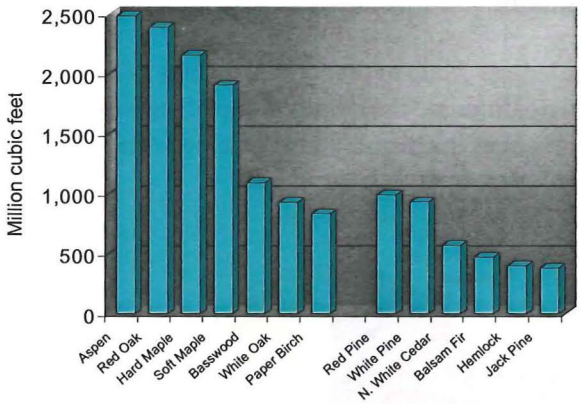


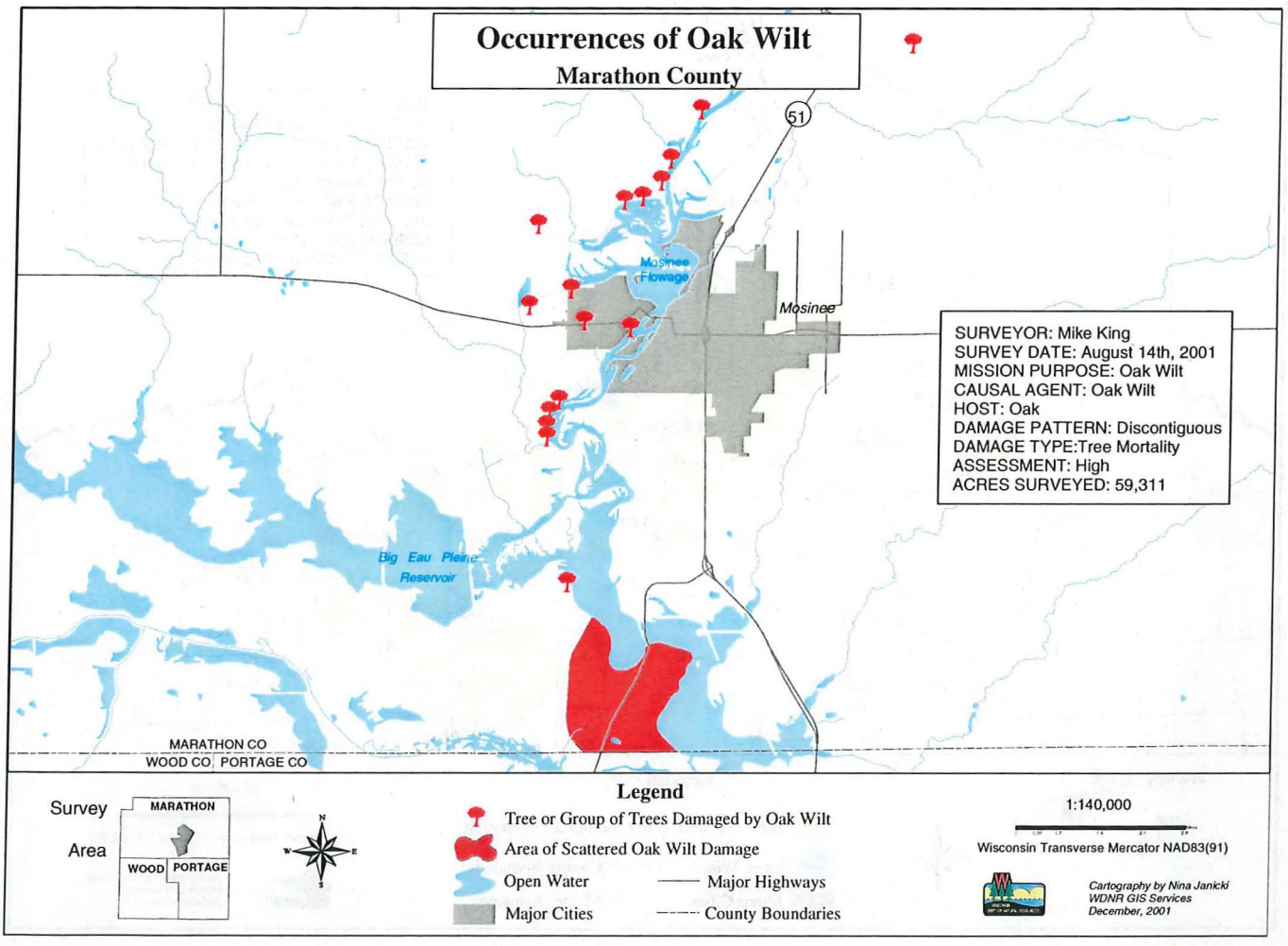
Figure 4. Most commonhardwood and conifer species (in million cubic feet) on timberland in Wisconsin. Data taken from 1996 FIA survey.

Major Issues

Oak Wilt

Oak wilt *(Ceratocystis fagacearum)*, active in Wisconsin for decades, continues to infect and kill oaks in pockets throughout the southern 2/3 of Wisconsin. No new counties reported the presence of oak wilt in 2001. Efforts on oak wilt centered on localized surveys such as the one conducted in Marathon County (see map). Emphasis on management of oak wilt continues to focus on prevention through limiting cutting and wounding of oaks during the high risk period from April 15 to July 1 and local spread management through root graft disruption, sanitation of infectious material and occasional use of a fungistat.

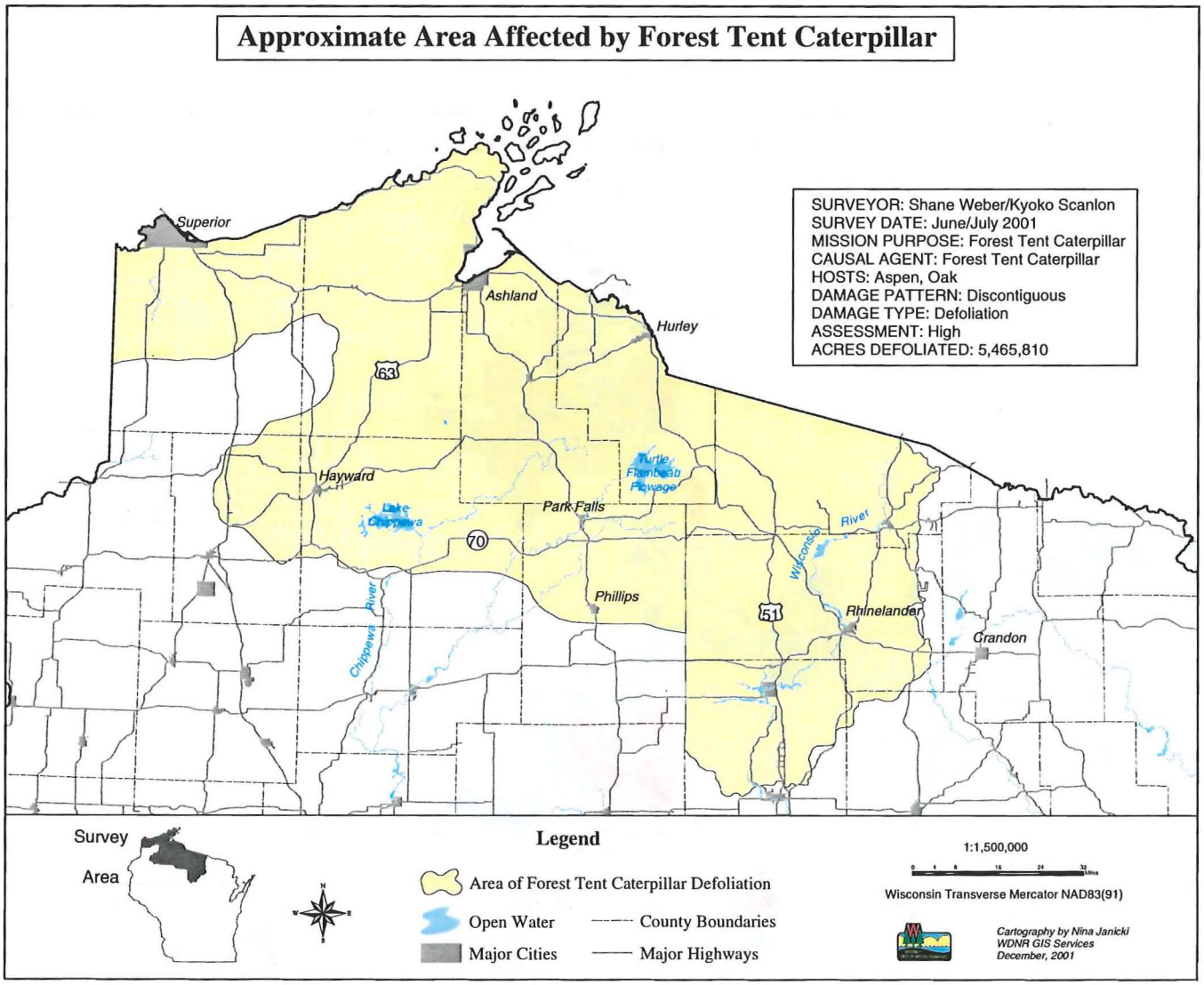
A full report on a 5-year survey of oaks pruned by Alliant Energy appears in the "special surveys" section at the end of this report.



Forest Tent Caterpillar

—Forest tent caterpillars (*Melanocarpa disstria*) caused heavy defoliation on many deciduous trees and shrubs, mainly aspen, oak, and birch, throughout northern Wisconsin. The defoliation was most severe in Ashland, Bayfield, Iron, Price, Vilas, Oneida, and Lincoln counties. Approximately 3,742,300 acres were defoliated in northwest Wisconsin with an additional 1,723,500 acres of defoliation in the northeast region. Large numbers of caterpillars caused light to moderate defoliation in Clark, Marathon, Portage, and Wood counties.

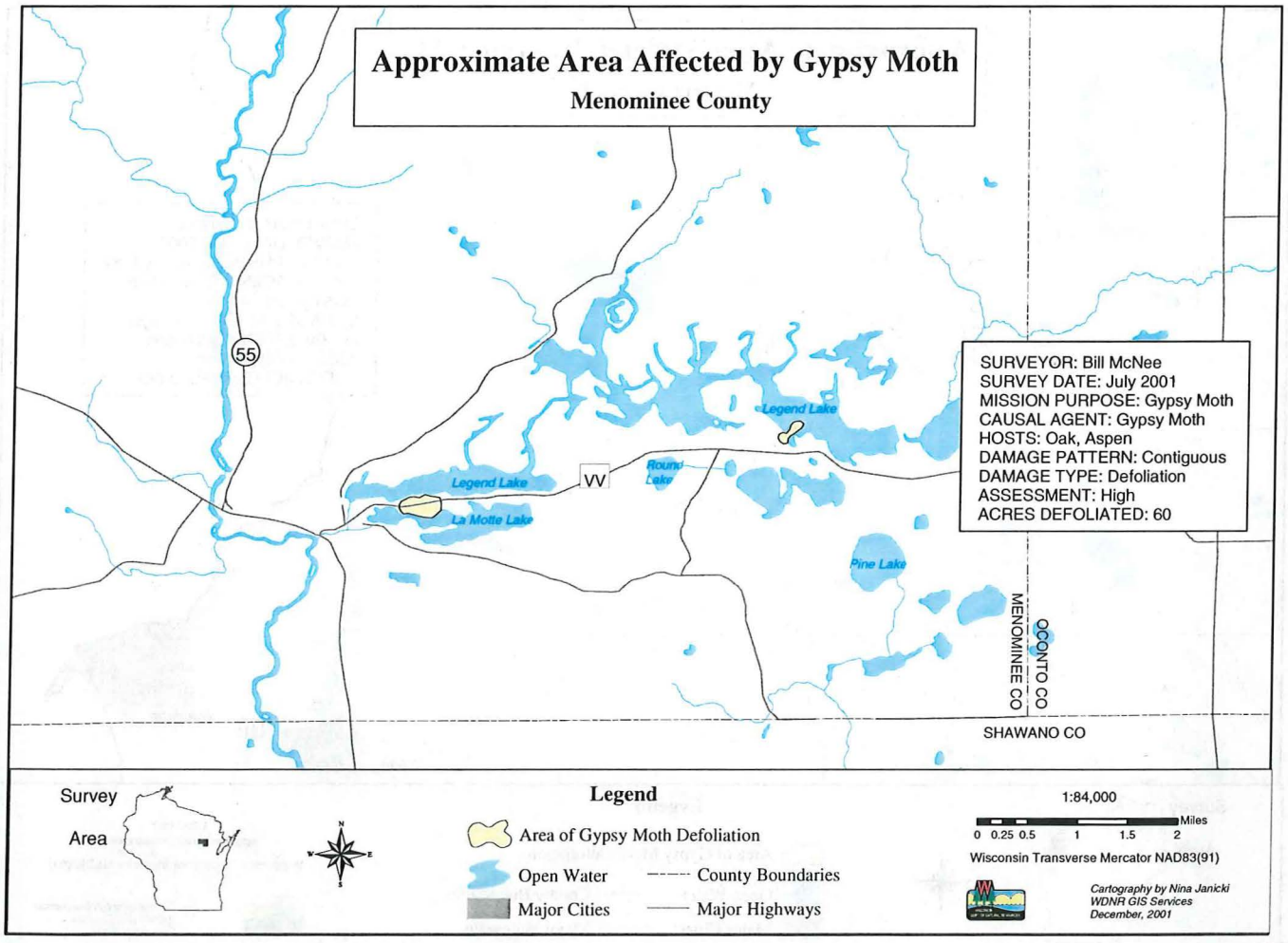
An outbreak of this insect has been occurring in Wisconsin since 1999, but the areas damaged this year were much larger than in the two previous years.



Gypsy Moth

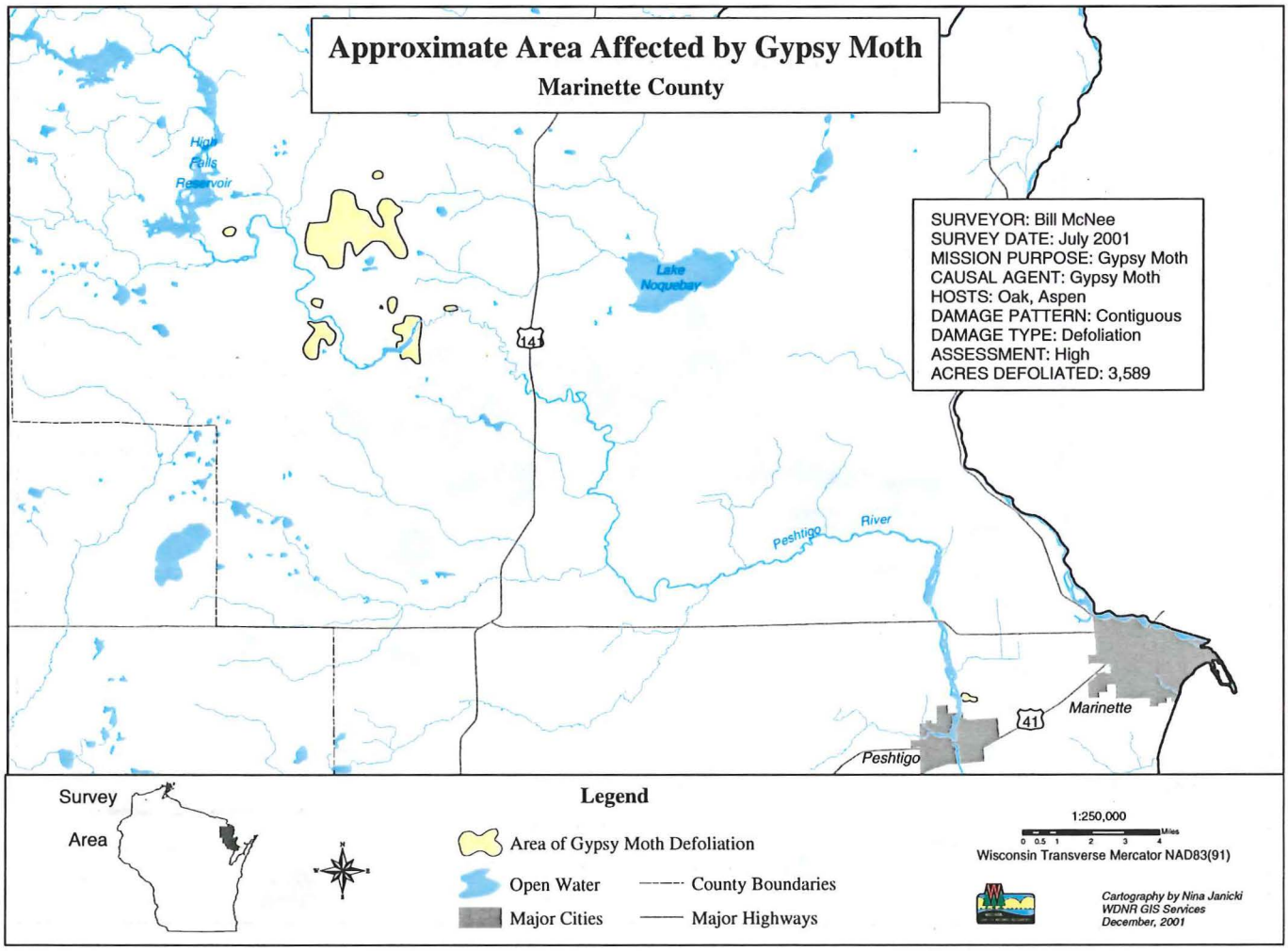
—Wisconsin's gypsy moth suppression program continued to grow, as the number of participating counties increased from 2 in 2000-2001 to 9 in 2001-2002. In 2001 approximately 1,400 acres in Appleton and Brookfield were treated with Btk in order to suppress outbreaking populations. Approximately 2,700 acres of heavy defoliation was observed in Marinette and Menominee Counties (see maps below) in northeast Wisconsin, and scattered patches of light and moderate defoliation were also seen. Defoliation in the Kettle Moraine State Forest of southeast Wisconsin was prevented by weather conditions favorable for growth of the pathogenic fungus *Entomophaga maimaiga.*

Nearly 175,000 acres were treated by the Wisconsin Department of Agriculture, Trade, and Consumer Protection (DATCP) as part of the national slow-the-spread program. Pheromone monitoring by DATCP trapped an increased number of moths in 2001, compared to prior years. Nuisance caterpillars generated a large number of



landowner calls from the Milwaukee and Green Bay metropolitan areas, and from several rural regions in eastern Wisconsin. Biological control agents were distributed to a number of cities for introduction, and the DNR's gypsy moth education program expanded considerably.

Egg mass surveys predict another year of heavy defoliation in selected portions of northeast and southeast Wisconsin where treatment was not requested by landowners or municipalities. In 2002, aerial suppression treatments are proposed for approximately 6,000 acres at 42 sites. Approximately 330,000 acres are proposed for treatment by the state's slow-the-spread program, mostly with pheromone flakes. The most dramatic change was observed in western Waupaca County, where the number of trapped moths grew approximately 12 fold compared to 2000 trapping. In 2002 patches of defoliation and large numbers of landowner calls are anticipated in this area.

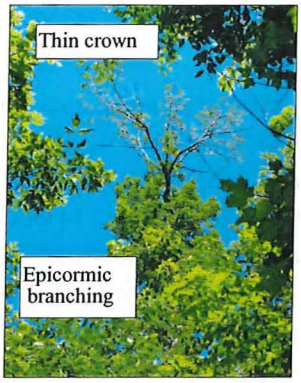


Minor Issues

Ash Yellows - Phytoplasma

Brooms often form at the base of trees infected with ash yellows.

—Ash yellows is a disease that affects all ash species in Wisconsin and is caused by a phytoplasma. These organisms slow the growth of ash trees, cause crown dieback and decline, and can lead to premature death. Ash yellows has been found in ten counties in Wisconsin: Brown, Calumet, Dane, Door, Sauk, Marathon, Manitowoc, Ozaukee, Sheboygan, and Waukesha counties.



Trees with ash yellows often have thinning crowns with tufts of small lighter colored leaves, epicormic branching along the main stem of the tree and brooms either on the main stem or at the base. Cracks are also common at the base of infected trees. The epicormic branches can appear healthy while the crown is noticeably in decline.

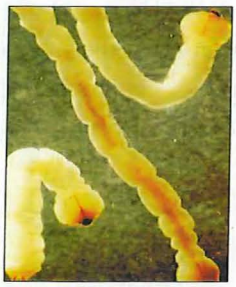
Oak tatters

—Oak tatters was observed on scattered white and bur oaks throughout the southern two-thirds of Wisconsin this spring. Oak tatters causes newly emerging leaves to develop very little leaf material between the veins, giving leaves a lacy, skeletal, or "tattered" appearance. Trees which are severely affected will attempt to send out a new set of leaves which are often free from tatters. Oak tatters is apparently caused by some sort of damage to the leaf tissue while it is still in the bud or when the leaves are first emerging. The exact type of damage is not known but possible causes include: cold temperatures, insects, and herbicide injury.

Tar spot

—Tar spot (*Rhytisma spp.*) is a cosmetic disease of maple trees that causes large black spots on the leaves. Some areas of Wisconsin had particularly high levels of infection in 2001 which caused the leaves to brown and curl. Infection of leaf material occurs in the spring and early summer but the characteristic black "tar spot" fruiting body doesn't show up until late summer. The leaves will drop in the fall and fruiting bodies will fully develop to release ascospores the following spring, these will then infect the newly emerging leaves if weather conditions are right.

Two-lined Chestnut Borer



—Mortality of mature oak was observed in the Northern Region, especially in Bayfield, Douglas, Oneida, Price, Sawyer, Vilas, and Washburn counties. Mortality was caused by two-lined chestnut borers (*Agrilus bilineatus*), native flat-headed wood boring beetles. Most of the sites with infested trees suffered an infestation by forest tent caterpillars for several years. On the western side of the region, oak mortality was much more prevalent on northern pin oaks

growing on light sandy soil. It is suspected that repeated years of defoliation by forest tent caterpillars, and hot and dry weather in July when defoliated trees were producing a second set of leaves caused extreme stress on trees to allow secondary pests to attack and cause oak mortality.

Larch beetle

—Mortality and dieback of mature tamarack were noticed in Oneida and Sawyer counties. The dead and dying trees were infested with larch beetles. Although larch beetles could attack healthy trees, they are usually considered a secondary pest, attacking stressed and recently cut trees. In Oneida County, most stands that were infested with larch beetles had suffered defoliation by larch casebearers for two to four years. In Sawyer County, however, the trees had appeared vigorous prior to sudden death with no obvious stress factors present. A similar pattern of *Dendroctonus simplex* was reported to have caused larch mortality in Minnesota.

Red-headed Pine Sawfly

—The larvae of the redheaded pine sawfly caused moderate to heavy defoliation on red pine in Vilas and Oneida counties. Both current and previous years' needles were consumed by this insect. In heavily infested areas, many trees were completely defoliated. An insecticide, malathion, was applied to protect a young red pine plantation from this insect in the Oneida County Forest.

Annosum Root Rot Update

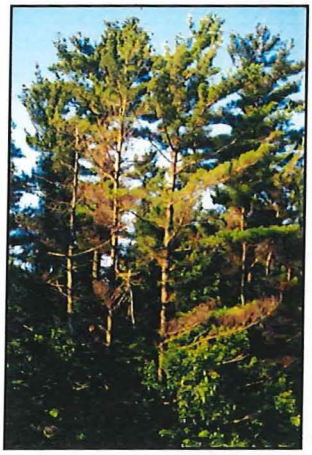
—Annosum root rot (*Heterobasidion annosum*) was first reported killing plantation pine in 1993. The most recent new confirmation of the disease occurred in Marquette County. In addition, Sauk, Richland, Iowa, and Adams counties have confirmed infection centers. It is primarily a concern in managed pine plantations in Wisconsin. The primary mode of infection is by spores germinating on fresh cut stumps and advancing through grafted root systems to healthy trees. As the disease advances a "pocket" of tree mortality occurs. It is recommended that in counties where annosum root rot has been confirmed, all fresh cut stumps be treated with "Sporax" which prevents spore germination. For more information and other preventative measures see the attached handout. Report any suspicious pine "pockets" to your regional forest health specialist.

A biological control trial was also initiated last year at two locations (Sauk and Iowa counties) to reduce spread of this disease. The trial included a salvage harvest along with a stand thinning. A 30' barrier zone was created around the infection centers. Stumps in the harvested barrier zone were treated with the fungus *Phlebiopsis gigantea* in hopes that the fungus will colonize the stumps around the infection centers and stop disease spread through grafted roots. A sanitation burn of the cut infected trees was also conducted this past winter. Phase two of the stump treatment trial will continue in 2002 with an additional 24 infection centers being treated*. Currently *P. gigantea* is not commercially available for general public use.

**See Special Survey Section in this publication for a full report.*

White pine needle discoloration - Sodium toxicity and unknown

—Reports of discoloration of white pine foliage, and occasionally red pine, started in 1999 and have continued through 2001. Most reports have the following characteristics:



1) Affected trees are typically more than 25 feet tall.
2) Symptoms include chlorosis of previous year's and current year's foliage. Chlorosis and necrosis is most noticeable on the needle tips.
3) Current year's foliage is typically stunted; shoot elongation is also minimal.
4) Premature needle loss is common.
5) Symptoms are most common on roadside white pine but are also present on woodland white pine.
6) Symptoms are most common in western and central Wisconsin.

Soil and foliage samples were collected from Monroe, Jackson and Wood counties. Analysis was conducted by the University of Wisconsin plant and soil analysis laboratory together with Dr. Jaya Iyer, soil scientist. Six of the trees sampled revealed the following levels of sodium (Na) in the foliage along with the following soil pH levels. All of these samples were collected from trees along a road or in areas where snow was plowed and dumped.

Sample No.	Foliage Na (%)	Calcium (%)	Soil pH
1	0.10	0.06	6.6
2	0.43	0.04	6.7
3	0.23	0.10	7.0
4	0.19	0.10	6.9
5	0.70	0.24	6.9
6	0.34	0.11	6.1

The results reveled an unhealthy ratio of sodium to calcium, indicating sodium toxicity. The high levels of sodium in the soil can cause displacement of the calcium, reducing its presence in the soil sample. Discussions with Dr. Iyer lead to the diagnosis of injury due to high levels of sodium. Sodium chloride is commonly used on roads to melt the ice. Leaching of sodium into the soil can increase the soluable salt content of the soil solution which in turn, increases the osmotic pressure of the soil solution. This draws water from the roots, causing plasmolysis or dehydration of root cells. Excess sodium will also raise the soil pH, which compounds the problem. A more suitable pH for white pine is between 5.5 and 6.5. Irrigation, to leach the sodium from the root area was recommended.

Samples collected from trees further from the highway did not reveal the same high levels of sodium, or the high pH. Results of soil and foliage samples from trees further off the highway did not show any pattern of nutrient toxicity or deficiency. The cause of chlorosis and necrosis of these trees is still unknown.

Other Pests Reported in 2001

Pest	Host	Damage	Location
Ash			
Anthracnose *(Gnomoniella fraxini)*	Green ash	Leaf margin browning & curling	Lincoln and Oneida Counties Manitowoc Co.
Ash leaf gall mite *(Aceria spp.)*	Green ash	Galls on upper leaf surface	Oneida County
Ash plant bug *(Tropidosteptes amoenus)*	Green ash White ash	Stippling and leaf drop	Washburn and Sawyer counties, much less damage than last year
Ash Yellows	Ash	Decline	Door, Manitowoc Co.
Forest tent caterpillar *(Malacosoma disstria)*	Ash	Defoliation	Brown, Shawano, Outagamie, and Winnebago counties
Mountain ash sawfly *(Pristiphora geniculata)*	Rowan tree	Defoliation	Present but at reduced populations across northwest Wisconsin
Unknown	Green ash White ash	Trees late leafing-out, thin crowned	Scattered throughout the WCR
Unknown	Ash	Dieback	Suamico in Brown County
Aspen			
Aspen blotch miner *(Phyllonorycter spp.)*	Aspen	Moderate to severe mining damage	Florence, Lincoln, Oneida counties, moderate damage in Sawyer, Price, Ashland & Iron counties
Forest tent caterpillar *(Malacosoma disstria)*	Aspen	Moderate to heavy defoliation	Throughout the Northern Region Marinette County
Balsam Fir			
Rhizosphaera needlecast *(Rhizosphaera pini)*	Balsam Fir	Needle discoloration and loss.	Clark County
Needle Scale	Balsam Fir	Slight feeding on needles.	Clark County
Spider mites *(Oligonychus ununguis)*	Balsam Fir	Chlorosis of needles.	Clark County
Basswood			
Introduced basswood thrips *(Thrips calcaratus)*	Basswood	Light-moderate defoliation	Small area (~2000 a) in southern Bayfield County
Black Walnut			
Fall webworm *(Hyphantria cunea)*	Black Walnut, Cherry, Willow	Numerous nests with light defoliation.	Numerous southern Wisconsin counties.
Cherry			
Armillaria	Black cherry	Root rot	Dane County
Eastern tent caterpillar *(Malacosoma americanum)*	Wild Cherry Flowering Crabs Wild plum	Defoliation and white tents on trees	Scattered in West Central Region Green County Washburn, Burnett, Barron, Washburn and Polk counties

Pest	Host	Damage	Location

Cherry (cont.)

Peach bark beetle *(Phloetribus liminaris)*	Black cherry	Attacking bole of trees (see pest alert)	Columbia County
Uglynest Caterpillar *(Archips cerasivorana)*	Wild Cherry	Defoliation	Very low populations in Burnett County

Christmas Trees

Balsam twig aphid *(Mindarus abietinus)*	Balsam fir	Curled needles	Lincoln County
Eastern spruce gall adelgid *(Adelgies abietis)*	Spruce	Pineapple shaped galls on twigs.	Chippewa County
Rhizosphaera needlecast *(Rhizosphaera spp.)*	Spruce and Balsam Fir	Needle discoloration and loss.	Chippewa, Clark counties Kewaunee County
Spider mites *(Oligonychus ununguis)*	Balsam Fir, Spruce	Chlorosis of needles.	Clark County
White pine weevil *(Pissodes strobi)*	White Spruce	Leader mortality.	Chippewa County

Crab Apple

Eastern tent caterpillar *(Malacosoma americanum)*	Flowering crab	White tents in trees and defoliation.	Scattered throughout the WCR.

Elm

Dutch elm disease *(Ophiostoma ulmi)*	Elm	Death	Entire Northeast Region

Hackberry

Mites	Hackberry	Leaves cupped and scortch looking	Dane County

Larch

Larch needlecast *(Mycosphaerella laricina)*	European larch	About 50% defoliation occurred on c. 50% of trees	Lorraine township, Polk County
Spider mites *(Oligonychus ununguis)*	Larch	Chlorosis of needles.	Wood County

Maple

Fall webworm *(Hyphantria cunia)*	Tag alder	Moderate populations	Sawyer and Price counties
Gall mites *(Eriophyid mites)*	Red maple Sugar maple	Bladder, erenium, and spindle galls on leaves	Throughout the Headwaters Basin

Pest	Host	Damage	Location
Lecanium scale *(Parthenolecanium spp.)*	Maple	Twig dieback	Throughout the Headwaters Basin
Maple leafroller *(Sparganothis acerivorana)*	Sugar maple	Light to moderate defoliation	Oneida County
Maple petiole borer *(Caulocampus acericaulis)*	Sugar Maple	Leaf drop.	Sawyer and Ashland counties
Maple webworm *(Tetralopha asperatella)*	Sugar maple	Webbing/leaf feeding	Forest and Vilas Counties
Tar Spot	Silver maple	Leaf damage	Manitowoc, Calumet, Outagamie counties.
Woolly Alder Aphid *(Prociphilus tessellatus)*	Silver Maple	White woolly insects flying around and/or on leaves. Honeydew dripping down on vehicles, decks, etc. and sooty mold forming on those various surfaces.	Scattered in West Central Region.

Oak

Anthracnose	White oak	Leaf damage	Many counties in the NER
	Red oak	Browning and curling of leaves.	Wood and Juneau counties
	Bur and white oak	Moderate to severe leaf damage	Dane and Rock counties
	Northern pin oak	Light to moderate damage	Washburn and Burnett counties
Armillaria	Oak sp.	Root rot	Dane County
Forest tent caterpillar *(Malacosoma disstraia)*	Red oak	Moderate to heavy defoliation	Throughout the Northern Region
Actinopelte Leaf Spot (Actinopelte dryina)	Bur oak	Leaf spotting, refoliation, and associated mortality	Lafayette County
Kermes scale *(Kermes spp.)*	Red oak	Twig dieback	Oneida County
	Oak (sp.)	Twig damage	Rock County
	Oak (sp)	Mortality in regeneration and branch mortality of overstory oak	southern Washburn County
Two-lined chestnut borer *(Agrilus bilineatus)*	Oak	Scattered moderate mortality following defoliation by forest tent caterpillar	Douglas and Bayfield counties Oneida and Vilas counties
Postoak locust *(Dendrotettix quercus)*	Red oak	Defoliation	Monroe and Juneau counties
Oak tatters	Red and White Oak	Defoliation.	Shawano, Menominee, Outagamie and Waupaca counties
	Red oak	Malformed leaves	Scattered throughout West Central Region
Oak wilt *(Ceratocystis fagacearum)*	Red oak	Wilted foliage and mortality	Scattered throughout West central region Florence County
Spring frost damage	Scrub oak Northern red oak	Forest in late May caused light to severe damage. Some scrub oaks were completely defoliated. Heavily damaged trees refoliated.	Florence, Lincoln, Oneida counties
Yellownecked caterpillar *(Datana ministra)*	White oak	Defoliation	Oconto County

Pest	Host	Damage	Location
Pine			
Aphids *(Cinara spp)*	Jack, red, scotch, and white pine	Some shoot dieback from feeding and associated black sooty mold	Scattered throughout West Central Region
Armillaria root rot *(Armillaria mellea)*	Jack, red, scotch, and white pine	Some seedling and tree mortality	Scattered throughout West Central Region
	Red Pine	Kills about 5% of small trees	Washburn County Northern Highland State Forest
Bark beetles *(Pityogenes hopkinsi)*	White pine	Attacking bole of yard trees	Waukesha County
Eastern pine shoot borer *(Eucosoma gloriola)*	Jack pine	Branch mortality.	Adams and Juneau counties.
European Pine Sawfly		Defoliation	Outagamie Co.
Gall Rust *(Cronartium spp)* *(Endocronartium spp.)*	Jack and Scotch pines	Bole and branch galls causing some mortality.	Scattered throughout West Central Region
Introduced pine sawfly *(Diprion similis)*	White pine	Light defoliation	Oneida County
Ips bark beetles *(Ips spp)*	Jack, red, and scotch pine	Tree mortality.	Scattered throughout West Central Region
	Red pine	Above normal populations cause secondary mortality in wind and hail damaged stands	Douglas County
	Red pine	Mortality	Waupaca, Waushara, Oconto, and Marinette counties
Jack pine budworm *(Choristoneura pinus)*	Jack Pine	Defoliation - light in Adams County, light to moderate in Juneau County.	Adams and Juneau counties.
Pine false webworm *(Acantholyda erythrocephala)*	White pine	Webbing and needle feeding	Langlade County
Pine Spittlebug *(Aphrophora cribrata)*	White pine	Feeding on branches	Vilas County
	Jack, Scotch, and white pines	Spittlemasses on bole and branches, little damage	Scattered throughout West Central Region
Red pine needlemidge	Red pine	Moderate damage	Small area in Gordon
Redheaded Pine Sawfly *(Neodiprion lecontei)*	Jack pine	Defoliation of saplings.	Jackson County
	Red pine	Heavy defoliation	Marinette, Oneida, and Vilas counties
Red pine pocket decline	Red Pine	Tree mortality and general decline of trees Leptographium present	Scattered in West Central Region.Florence County, Columbia County, Waushara County
Pine rot tip weevil *(Hylobius rhizophagus)*	Red and jack pine	Dieback in poor sites	Northwest Wisconsin
Red Turpintine Beetles *(Dendroctonus valens)*	Red Pine	General decline of trees.	Adams County
Saratoga spittlebug *(Aphrophora saratogensis)*	Red pine	Flagging	Oneida County

Pest	Host	Damage	Location
Pine (continued)			
Sphaeropsis collar rot and shoot blight *(Sphaeropsis sapinea)*	Red and jack pine	Very common in hail damaged stands causing high mortality of young pine	Douglas County
	Red and Scotch pines	Seedling/sapling mortality (collar rot), to shoot and branch mortality.	Scattered throughout WCR.
White Pine Weevil *(Pissodes strobi)*	Jack Pine	Dying terminal leaders with shepherds crooks.	Adams and Juneau counties
Zimmerman Pine Moth *(Dioryctria zimmermani)*	Jack, Scotch, and white pines	Branch mortality and damage to main bole.	Scattered in West Central Region.
Spruce			
Aphids *(Cinara spp)*	Spruce	Chlorosis of needles.	Chippewa County
Chlorosis	White spruce	Lack of vigor	Winnebago, Fond du Lac Co's
	Spruce	Problem with soil Ph	Pierce County
Eastern spruce gall adelgid *(Aldelges abietis)*	White spruce	Galls on twigs	Lincoln County
Spider mites *(Oligonychus ununguis)*	Spruce	Chlorosis of needles.	Chippewa County
Spruce needle rust *(Chrysomyxa spp.)*	Colorado blue spruce	Needle loss	Oneida County
Rhizosphaera needlecast *(Rhizosphaera kalkhoffii)*	Blue Spruce	Needle loss	Door Co.
Winter injury	Spruce	Browning of needles.	Chippewa County
Tamarack			
Larch casebearer *(Coleophora laricella)*	Tamarack	Moderate to heavy defoliation	Throughout the Headwaters Basin
Larch beetle *(Dendroctonus simplex)*	Tamarack	Decline/mortality	Oneida County
Larch bark beetle *(Dendroctonus simplex)*	Tamarack	Tree mortality	Brown and Winnebago counties
Willow			
Imported willow leaf beetles *(Plagiodera versicolora)*	Willow	Moderate to severe feeding damage	Oneida County
Miscellaneous Pests			
Japanese Beetle (Popillia japonica)	Various trees and shrubs.	Brown patches in lawns (larval feeding) to leaf feeding (sketetonizing of leaves).	City of Eau Claire and Eau Claire County.
Abiotic Factors			
Hail Damage	Jack, red, and white pines, and oaks.	Size of hail ranged from a dime to golf ball size. Wounds to pines included the main bole and branches and leaf tattering in the oaks. Sphaeropsis Shoot Blight took advantage of the wounds in pines and Bark Beetles were also moving in. Severe dieback and mortality was occurring in the pines. Salvage harvests were being planned for the severely affected pines.	Monroe, Pepin, and Pierce counties. Over 15,000 acres in Douglas County

Special Surveys

Jack Pine Budworm Survey Procedures and Results: 2001

Shane Weber, DNR Forest Entomologist
Dept of Natural Resources
Spooner, Wisconsin

Early larval survey

This survey is done on a yearly basis and is a key indicator of the presence of destructive budworm populations. Thirty shoots and staminate flowers (15 of each) that can be reached from the ground are checked for larvae. Since staminate flowers are often scarce, a majority of shots are usually used. A count of 20 or more infested shoots and flowers is considered sufficient to cause moderate to severe defoliation.

Early Larval Populations

County	No. Plots	No. Infected Shoots	Infected Shoots/ Plots	No. High Plots	% High Plots
Polk	15	90	6.00	4	26.7
Burnett	24	20	0.83	0	0
Washburn	21	11	0.52	0	0
Douglas	53	15	0.28	0	0
Bayfield	32	4	0.13	0	0
District	**145**	**140**	**0.97**	**4**	**2.8**

Early Larval Population Trends

	No. Infested Shoots/Plot						% High Plots				
County	**1997**	**1998**	**1999**	**2000**	**2001**	**%Change 1999-2000**	**1997**	**1998**	**1999**	**2000**	**2001**
Polk	0.93	0.67	2.60	2.47	6.00	**+143**	0	0	13.3	6.7	26.7
Burnett	0.78	1.46	1.29	1.08	0.83	**-23**	0	4.2	4.2	0	0
Washburn	1.90	7.14	6.57	0.24	0.52	**+117**	5.0	28.6	28.6	0	0
Douglas	10.84	13.03	4.17	0.36	0.28	**-22**	60.8	81.5	9.3	0	0
Bayfield	13.43	7.47	1.63	0.09	0.13	**+44**	67.9	25.0	0	0	0
District	**7.29**	**7.79**	**3.32**	**0.62**	**0.97**	**+56**	**37.2**	**40.4**	**9.6**	**0.7**	**2.8**

Jack Pine Budworm Pupal Survey

This survey is also conducted annually and gives a good indication of the kinds and numbers of pupal parasites in the population as well as next year's population of jack pine budworm. It is done in July when most insects are in the pupal stage. Some adults may already have emerged, but empty pupal cases are collected and counted as emerged moths. At each stop, pupae are collected on a time basis. If five pupae are not found in five minutes, the collection is terminated. If five pupae are found in 5 minutes or less, the collection is continued until 25 pupae are found or until 15 minutes have elapsed. The time required to find 25 pupae is then recorded. Adults, parasites and non-emergence are recorded for each pupae.

Pupal Survey

				Moths		Parasites		Not Emerged	
County	Total Pupae	Total Minutes	Pupae/ Min	No.	%	No.	%	No.	%
Polk	54	95	0.57	16	29.6	34	63.0	4	7.4
Burnett	40	128	0.31	25	62.5	13	32.5	2	5.0
Washburn	14	105	0.13	10	71.-45	3	21.4	1	7.2
Douglas	34	270	0.13	25	73.5	7	20.6	2	5.9
Bayfield	4	160	0.03	2	50.0	2	50.0	0	0
District	**146**	**758**	**0.19**	**78**	**53.4**	**59**	**40.4**	**9**	**6.2**

Pupal Population Trends

County	1998 Pupae/min	1999 Pupae/min	2000 Pupae/min	2001 Pupae/min	% Change 1999-2000
Polk	0.37	0.63	0.74	0.57	-23
Burnett	0.39	0.44	0.21	0.31	+48
Washburn	1.45	0.66	0.07	0.13	+86
Douglas	1.30	0.13	0.05	0.13	+160
Bayfield	0.98	0.03	0.01	0.03	+200
District	**1.08**	**0.32**	**0.15**	**0.19**	**+27**

Jack Pine Budworm Parasite and Predator Complex

This survey involves a careful examination of all the budworm pupae collected which do not produce moths. Adult specimens are compared to a reference collection. Any unknown adults are sent to the University of Wisconsin for identification. Pupal cases from which nothing emerges are dissected to ascertain the cause of failure.

Parasite/ Predators	Polk	Burnett	Washburn	Douglas	Bayfield	Total	% of Parasitized	% of Total
Itoplectes	9	2	0	1	2	14	23.7	9.6
Scambus	1	0	0	0	0	1	1.7	0.7
Phaogenes	1	4	1	3	0	9	15.3	6.2
Pteromalids	3	0	1	0	0	4	6.8	2.7
Tachinids	8	3	0	0	0	11	18.6	7.5
Predators	12	4	1	3	0	20	33.9	13.7
Total	**34**	**13**	**3**	**7**	**2**	**59**		

White Pine Blister Rust: Management Options in 2002

Sally Dahir, Forest Health Technician
Dept. of Natural Resources
Fitchburg, WI

History of Blister Rust Management in Wisconsin

Early days

Blister rust arrived on imported European nursery stock in c. 1915 in Polk County, Wisconsin. In Europe, the disease had devastated 5-needled pines mainly because of the abundance of cultivated gooseberry (*Ribes*) there. (*Ribes* is the alternate host to this disease.) In northern Wisconsin, however, wild *Ribes* florished on the cut-over and burned-over land and blister rust spread quickly. The fear that this disease might eliminate the entire white pine resource in Wisconsin led to the development of a control program as early as 1917. Pathologists with the USDA recommended the eradication of *Ribes* from near pine plantations. Data from the 1930's supported this approach. Interestingly, the pre-eradication abundance of *Ribes* (Figure 1) shows little correlation with the incidence of blister rust. This observation was to prove important later on in the gradual elimination of funding.

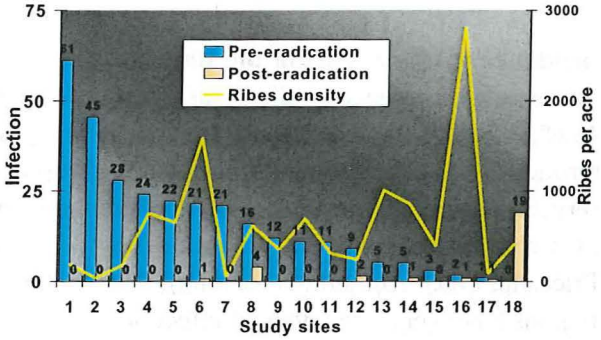


Figure 1. Data in the 1930's supported the eradication of Ribes but there was little correlation between Ribes density and rust levels.

USDA Ribes control program

The *Ribes* eradication program mushroomed during the Depression with the enrollment of large numbers of CCC workers (see figure). Funding between 1933 and 1934 went from $500,000 a year to $2.5 million annually and manpower increased from 1,000 to 11,000 men. However, with the beginning of US involvement in World War II, both manpower and funding became scarce. At the same time, several reports were issued which questioned the efficacy of the program. For instance, King published a study in 1958, in which he reported that local *Ribes* populations had little relation to levels of rust and that even a few bushes were sufficient to cause high levels of infection. He reported a disease incidence of only 3.4%.

Risk Mapping

With the collapse of the eradication program, the US Forest Service decided that a more practical approach would be to develop a map predicting where the relative risk of blister rust would be greatest and the forest manager could take precautions accordingly. Because the disease required cool, humid August temperatures, the map was based on average fall temperatures and rainfall (Figure 3). For risk zone 4, the zone of highest risk, the admonition of high losses despite preventive measures seemed to have the effect of discouraging the planting of white pine altogether. Since red pine was seen to be a disease-free alternative, many land managers decided to avoid the risk altogether by planting red pine instead of white. For instance, the acreage in seedling/sapling red pine went from 27,000 acres in 1938 to 186,000 acres in 1996, a six fold increase, whereas acreage in white pine went from 42,000 to 37,000 acres, a decrease of 12%, in the same time span.

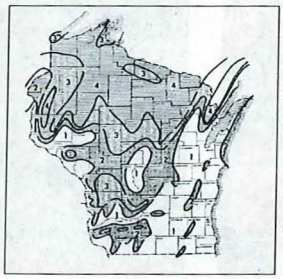
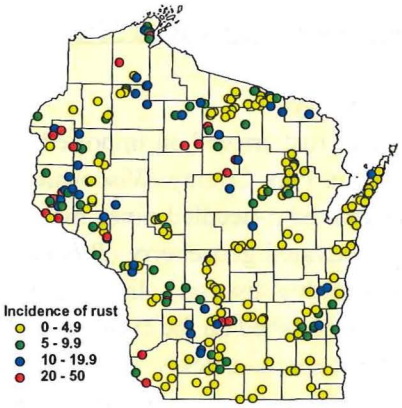


Figure 3. The risk of blister rust increased from zone 1 in the south to zone 4 in the north.

The situation in 2001

Several conditions had changed in **Wisconsin since 1915**: forests were older and closed canopy providing much poorer habitat for *Ribes*, studies revealed low levels of blister rust and groups like the Menomonee Indians were promoting the cultivation of white pine, insisting that the threat of rust and weevil could be controlled. For these reasons, we decided to conduct a study documenting both the incidence of blister rust throughout the state as well as site and stand characteristics related to rust incidence.



Incidence of blister rust in the state

The average incidence of blister rust was 7.1% statewide, ranging from 0% to 46.6% of all trees infected with rust. Over the 3 years of the study, from 1998 through 2001, a total of 279 stands were surveyed and 16,572 white pine observed. The highest average incidences are found in the west central region of St. Croix, Dunn and Pierce counties, Bayfield County and the area around Price and Lincoln counties (see map). Most of the southeast and south central regions have very low levels of infection.

Factors related to incidence

The factor with the highest and most consistent correlation with rust levels was the **proximity of *Ribes*** to the stand (Figure 4). The amount of *Ribes* did not seem to be important, as few bushes could cause high levels of infection if located near the pine. The position of trees with relationship to spore exposure seemed to be most important. For instance, hilltop stands had higher levels of rust due to greater exposure to spores carried by strong upslope air currents. In addition, higher levels of infection are found along the edge of a stand or adjacent to paths where air currents are channeled. Hardwood forests have a high incidence of *Ribes* in Wisconsin and when pines are planted close to the edge of these forests (Figure 5), much higher levels of infection may occur in the rows next to the woods than in the interior.

Figure 5. In this stand, very high levels of infection were found in the row adjacent to the woods where *Ribes* bushes were present.

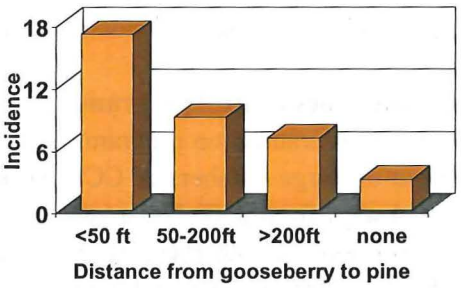


Figure 4. The incidence of rust decreases dramatically as distance from Ribes to pine increases.

Habitat type is also correlated with the incidence of blister rust (Figure 6). The levels of infection seem to increase as the average moisture and nutrient level of the soil increases. This is partly due to the fact that *Ribes* incidence increases with these factors. The occurrence of *Ribes* is very low on dry sites and up to 70% average incidence on mesic sitesHabitat type also affects the levels of humidity

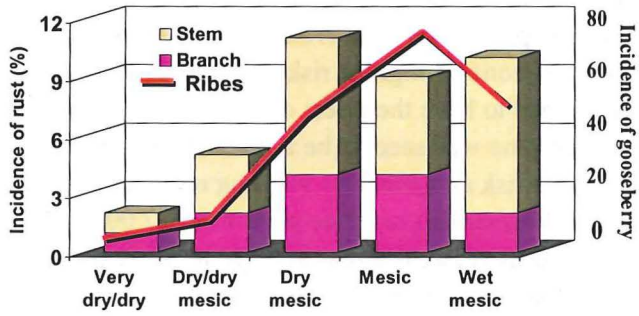


Figure 6. Rust levels are highest on habitat types where Ribes is most frequent.

Figure 7. Dry sites promote lower levels of humidity and greater air circulation around the lower branches.

and amount of air circulation around needles in the lower crown (Figure 7). Not only is foliage density often higher, but growth of weeds and grasses is usually more prolific on mesic sites. These conditions may be especially pronounced on hydromesic land or areas near wetlands and bodies of water. If *Ribes* is present on these sites, the incidence of rust may be especially high.

Tree age and size are correlated with infection levels (Figure 8) for several reasons. As a tree ages, the surface area of needles increases, foliage density is higher, and the tree will survive with the disease for a longer period of time. For instance, an infection on a needle on a pole-sized tree will take many years to grow down the branch and several more years to girdle the main stem, whereas a seedling will die within a few years.

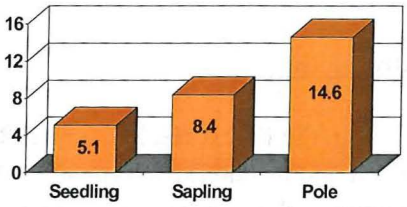


Figure 8. The incidence of rust is significantly higher in larger trees and older stands.

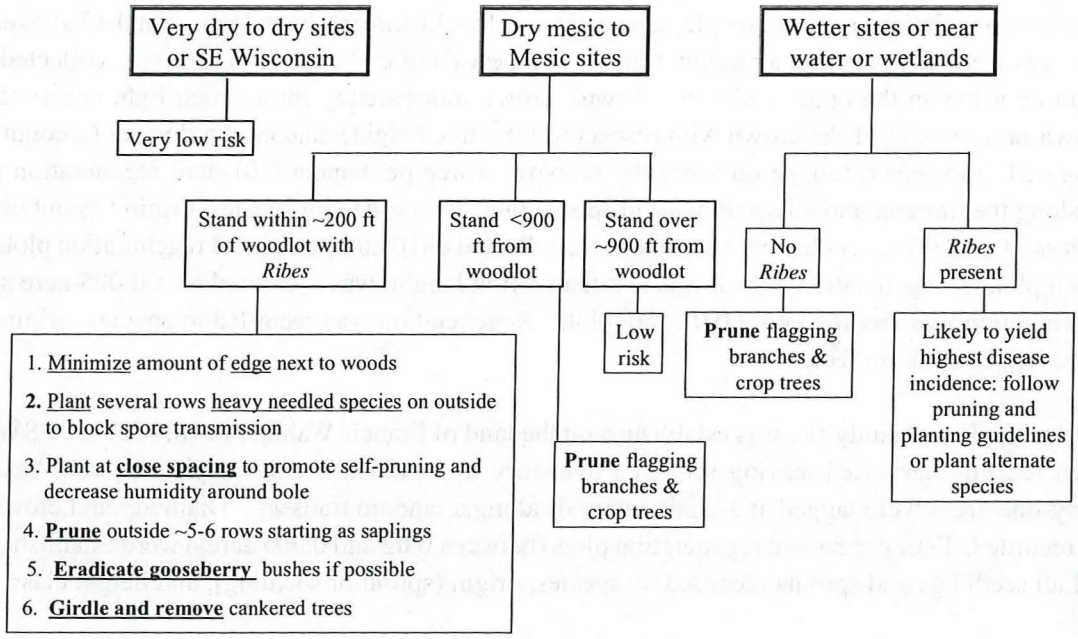
The **age of the stand** may also influence the level of rust infection in that the total amount of innoculum which builds up on *Ribes* in the summer and overwinters on white pine will increase over time. As a tree ages, its branches become larger and longer. As a canker grows up these branches from the needles to the bole, its surface area will be larger and it will take a longer time to grow toward the stem and eventually girdle the tree (Figure 9). This means that more aecia are produced each spring, more *Ribes* infected and more infections produced on the white pine in the fall. For this reason, it may be important not to plant stands of varying ages in close proximity as disease may spread from infected older trees to otherwise healthy seedlings. In addition, cankered branches should be removed (this will also save the tree) and trees with cankers on the main stem should be girdled and/or removed

Seedling **Pole**

Figure 9. A pole-sized tree has more needles, less air flow through the crown, and a longer period of exposure to infection.

Management Recommendations

The following management guidelines were developed to incorporate traditional silvicultural recommendations with observations from this survey as to where best to apply these recommendations


Very dry to dry sites or SE Wisconsin
Dry mesic to Mesic sites
Wetter sites or near water or wetlands
Very low risk
Stand within ~200 ft of woodlot with *Ribes*
Stand <900 ft from woodlot
Stand over ~900 ft from woodlot
No *Ribes*
Ribes present
Low risk
Prune flagging branches & crop trees
Likely to yield highest disease incidence: follow pruning and planting guidelines or plant alternate species
Prune flagging branches & crop trees
1. Minimize amount of edge next to woods
2. Plant several rows heavy needled species on outside to block spore transmission
3. Plant at **close spacing** to promote self-pruning and decrease humidity around bole
4. **Prune** outside ~5-6 rows starting as saplings
5. **Eradicate gooseberry** bushes if possible
6. **Girdle and remove** cankered trees

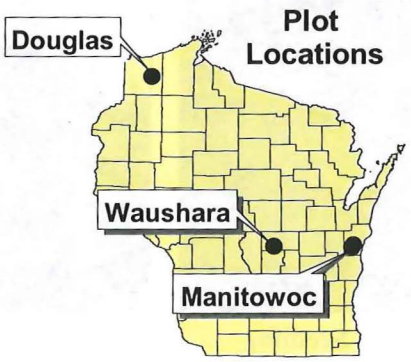
Wind and Hail Storm Damage 2000

Follow-up in 2001

Sally Dahir
Forest Health Technician
DNR Fitchburg WI

Introduction

In the Forest Health Annual Report of 2000, we documented the effects of 2 major wind and hail storms in central and northwest Wisconsin. The first, in May 2000, affected mainly Waushara, Marquette, and Manitowoc counties and the second, in August, hit Douglas and Juneau counties. Both storms involved very high wind speeds and large hail. Damage to softwood and hardwood overstory trees was extensive on all sites. Large hailstones created wounds on the branches and stems of trees and stripped developing buds and foliage. At that time, questions were raised as to the future health of affected trees. One of our major concerns was whether stands would recover to a merchantable condition or whether immediate harvest would prevent the proliferation of insect and disease problems. In naturally regenerated stands, we wanted to see both the effect of heavy overstory damage on regeneration as well as the impact of harvesting technique on the rates of sprout and seedling establishment.



In 2000, study sites were set up in Manitowoc, Waushara, and Douglas counties (see map) to establish baseline measures of overstory conditions immediately after the storms. Work in 2001 consisted of both plot remeasurement and new plot establishment to evaluate regeneration success, in both harvested and unharvested stands.

Methods

Manitowoc County

Two lowland sites were compared: a selectively cut woodlot belonging to Krueger Lumber Co. (T18N R22E S16 SENE) and another clearcut site belonging to Pete Wagner (T18N R22E S15 NWNE). Prior to the hailstorm, both woodlots had populations of silver maple, ash (green and black) elm and basswood. On the Krueger property, 31 damaged trees were tagged along a random transect at intervals of c. 3 chains. Data were collected on crown dieback (dead branches in the upper and outer crown); crown transparency (how much light comes through the foliage); crown ratio (height of the crown with respect to total tree height); and crown density (amount of foliage present compared to expected foliage on a healthy crown). Three permanent 0.01-acre regeneration plots were established along the transect and all seedlings and sprout clumps recorded by species, origin (sprout or seedling), and height class. On the Wagner clearcut site, data were collected on10 non-permanent regeneration plots - 3 chains apart. At each plot, all regeneration, which was less than 1 ft in height, was measured on a 0.005-acre subplot and all taller regeneration was recorded on a 0.02 acre plot. Regeneration was recorded to species, origin (sprout or seedling), and height class (in feet).

An upland hardwood study site was established on the land of Francis Waniger (T18N 22E S29 SWNE). This site had been recently harvested leaving scattered overstory trees, mostly sugar maple, red oak, basswood and beech. Thirty-one trees were tagged at 3-chain intervals along a random transect . Diameter and crown measurements were recorded. Four permanent regeneration plots (between 0.02 and 0.005 acres) were established along the transect and all seedlings and sprouts recorded by species, origin (sprout or seedling), and height class.

An upland conifer study site was established in 2000 and remeasured in 2001 on the land of Pete Wagner, private forestry consultant. In June 2000, one month following the storm, Pete recorded the species, diameter, crown class, tree age, and the amount of crown and height loss for 50 of the surviving red and white pines. He remeasured these 3 months later, adding 50 more to the study. In September 2001, 12 to 15 months after the initial measurement, we recorded the amount of crown and height loss as well as overall condition of these 100 pines.

Waushara County

In July 2000, a permanent plot was established in a red and white pine sapling stand in Waushara County (T18N R10E S18) which had been heavily damaged by hail in the May storm. One hundred white and red pine were tagged at 3 chain intervals along a random transect. The species, height (in feet), and previous 4-year height growth were recorded for each tree. In addition, the percent dieback of buds, shoots, and branches was estimated and the presence of a dead leader was noted. The tagged trees were remeasured in September 2001 for total height, percent foliage discoloration, and presence of a dead leader.

Douglas County

Random transects were established in July 2000 in 4 stands on the Brule River State Forest, Douglas County T45N R11W S4): two aspens stands, one sapling and one sawtimber, and two red pine stands, also one sapling and one sawtimber size class. In the both red pine plantations and in the sawtimber aspen stand, 100 trees were tagged in consecutive order along a random transect (within 3 ft.on either side of the transect). In the sapling aspen stand, 100 trees on a 0.02 acre circular plot were tagged. In the sapling aspen and red pine stands, only the diameter of tagged trees was recorded in 2000. In the sawtimber aspen stand, diameter and percentage of remaining foliage were recorded and in the sawtimber red pine stand, diameter and general crown condition were recorded. All trees were remeasured in September 2001 for percent crown dieback and the presence of a dead top. At this time, five 0.005 acre regeneration plots were established in each of the aspen stands and the number of aspen suckers recorded.

Results and Discussion

Manitowoc County

Lowland sites

The major difference between the Krueger selectively cut stand and the Wagner clearcut was the presence of silver maple regeneration in the latter and the absence of any maple regeneration in the former. Most of the silver maple had died in both stands but whereas the dead maple were cut on the Wagner property, most were left standing on the Krueger land. The majority of live trees (~90%) on this stand were ash (mostly black ash) with only ~6% silver maple. Crown dieback and transparency were low on the ash, 11% and 16%, reflecting the ability of ash to break new buds and produce dense bunches of foliage, especially along the bole. Live crown ratio and density were much reduced, averaging 62% and 70% respectively. These

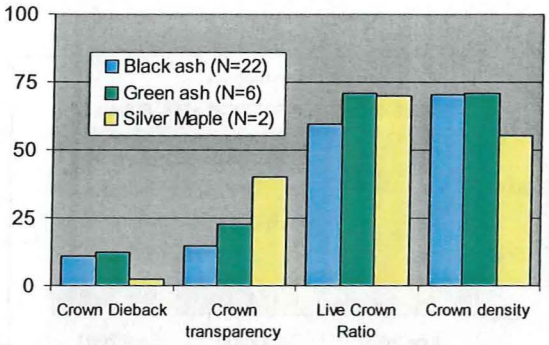


Figure 2. Crown density was fairly high and crown ratio low on the ashes and few silver maple that survived on the Krueger land.

Figure 1. Lowland stand belonging to Krueger lumber company. Notice the large number of dead standing timber and scarce dense foliage hugging the stems of surviving trees.

numbers describe crowns that tended to be dense and narrow, hugging the bole, with a fairly low amount of dead branches (Figure 1). Even though dieback was not severe in 2001, these narrow crowns with damaged branches are expected to show dieback in 2002. The 2 silver maples had higher crown transparency, 40%, and lower crown density, 55%, indicating silver maple's poor ability to produce new foliage(Figure 2) . In general, regeneration on the Wagner property which had been clearcut, was higher than the selectively-harvested Krueger stand (Figure 3). Regeneration of silver maple was not observed at all on regeneration plots on the Krueger land.

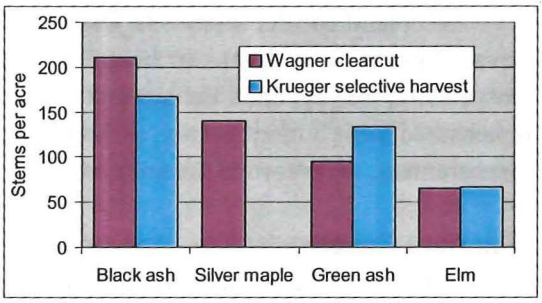


Figure 3. Regeneration of lowland species on the Wagner and Krueger properties. Clumps of sprouts are counted as 1 stem.

Figure 4. Dense competition may have impeded regernation on the Wagner clearcut.

Of the silver maple regeneration on the Wagner property, 78% were of sprout origin and only 22% seedling. Of the ashes, only 18% were sprouts on the Wagner property but about 75% were of sprout origin on the Krueger property where live overstory ash trees were still present. The few elms were all seedlings and the one basswood was a clump of sprouts. A very dense cover of a tall herbaceous plant called biden (latin name) could have impeded seedling germination in the Wagner clearcut (Figure 4). Herbaceous competition was much lower in the Krueger selectively cut stand.

Upland sites: Hardwoods

Figure 6. Trees that were left had on the Waniger hardwood stand after the storm and harvesting had fairly low live crown ratios and low crown densities.

The Waniger hardwood stand suffered severe hail damage. Most trees were harvested in hopes of salvaging what good lumber was left and allowing advanced regeneration to grow. Live crown ratio and crown density were quite low for the remaining sugar maple (Figure 6). Regeneration of hardwoods (Figure 7) appeared to be adequate.

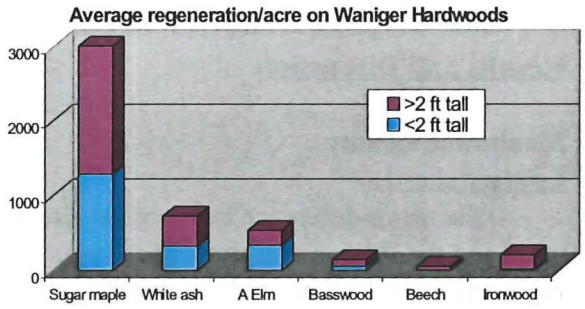


Figure 7. Regeneration of hardwoods was quite good on the upland hardwood site.

Upland sites: Conifers

On the Wagner pine plantation, results in the spring of 2000 seemed to indicate a favorable outcome. There was little visible damage and about half of the trees had 50% or less crown dieback. At the end of the first growing season there was a high correlation between initial (as measured in June) crown condition and mortality. Of 7 white pine with 90% crown loss, 6 were dead by September 2000.

After the second summer, however, mortality was much higher (Figure 8). Of 62 trees with over 30% crown dieback at the end of the first growing season, 77% (48) were dead by the

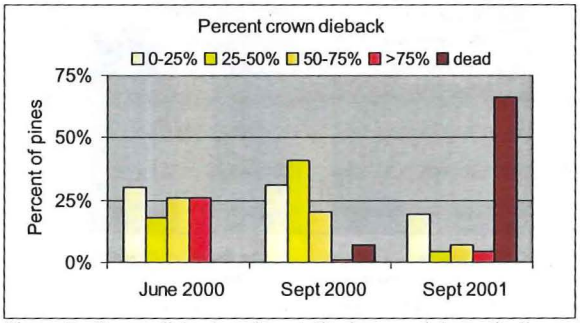


Figure 8. Crown dieback and mortality increased dramatically after the first growing season.

end of the second. Trees that had suffered moderate dieback in the first year after the storm were probably stressed by drought during the summer of 2001. White pine faired somewhat better than red pine. Initial leader loss was also correlated with dieback. Sixty-eight percent of pines with 3 or more feet of leader dieback after the storm were dead by the end of the following growing season (Sept, 2001). Of 10 trees with less than 2 ft. of initial leader dieback, 70% (7) had less than 50% crown dieback by Sept. 2001.

Waushara County

Figure 9. Red and white pine in Waushara County had high l eader mortality.

The trees don't look bad from a distance. Few brown needles and dead branches are seen. A closer look (Figure 9) reveals that many of the leaders are dead and that height growth will probably be stunted for several years. The bottom branches have flushed out well and appear normal. This is reflected in the statistics collected on dieback in both 2000 and 2001. While overall dieback decreased from 2000 to 2001, the percentage of dead leaders increased from 28% in 2000 to 61% in 2001. White pine leaders were hit much more severely than red pine in 2000 (71% and 5% dead leaders respectively) but in 2001 the number of dead leaders on red pine increased dramatically to 46% (89% of white pine leaders were dead in 2001).

Dieback recorded in 2000 soon after the storm, was negatively correlated with 2000 and 2001 height growths, especially for branch dieback (Figure 10). Interestingly, the tallest trees suffered less damage from hail, in terms of bud, shoot, branch, and leader mortality. Dieback is negatively related to 1999 tree height in both 2000 (p=0.005) and in 2001 (p=0.09). Tall trees also suffered significantly less leader damage: trees whose terminals survived the hail in 2000 averaged 8.2 feet in 1999 whereas trees whose leaders died in 2000, averaged only 7.1 feet in height prior to the storm.

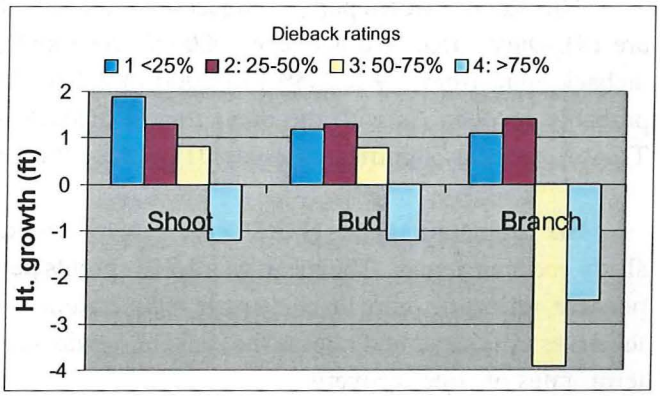


Figure 10. Red pine dieback ratings in 2000 were negatively correlated with height growth between 2000 and 2001.

Douglas County

Sapling Red Pine

The leaders had died on all tagged red pine saplings in 2001 (Figure 11) and most trees had lost at least 2 years of growth. The average dieback in 2001 was just over 50% of branches. This is much worse than the damage suffered to pines in Waushara county. As in Waushara, the largest trees suffered the least damage (p<0.001). This may be related to bark thickness.

Figure 11. Almost all red pine saplings had dead leaders.

Sawtimber Red Pine

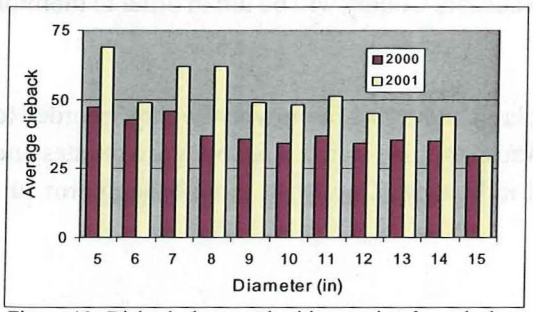


Figure 12. Dieback decreased with tree size for red pine.

Red pine sawtimber fared somewhat better than the saplings with respect to dieback and dead leaders. An estimated 50% (probably higher) had dead tops. Average dieback was 1.8 (c.36%) in 2000 and 2.4 (c.49%) in 2001. Trees with dead leaders in 2001 had much more dieback in 2000 (p=0.001) than those whose leader had survived. Only 1 of the 100 tagged trees had died between 2000 and 2001. Here as well (Figure 12), dieback decreased with tree size or diameter (significant.at

$p<0.01$). A pocket of dead pines on the stand has developed signs of bark beetle damage and the stand is also scheduled to be harvested within the next year.

Sapling aspen

The sapling aspen stand fared very poorly. One third (N=34) of tagged trees were dead in 2001. Another one third (33) had over 75% dieback and eighty percent of tagged trees had dead tops (Figure 13). Only 11% of trees had less than 50% dieback. Again dieback severity is significantly negatively correlated with tree size or dbh, i.e. larger trees suffer less damage. Regeneration from suckers is quite adequate. Five 1/200 acre regeneration plots were measured with an average 2,120 aspen suckers/acre. This stand will also be clearcut in order to open up the stand and encourage growth of the suckers.

Figure 13. Sapling aspen suffered very high mortality and crown dieback.

Sawtimber aspen

This stand suffered perhaps the least damage of all 4 types in Douglas County (Figure 14). Only 1 tree died between 2000 and 2001 and only 6% had dead tops. Average dieback went from 1.9 (c. 35%) in 2000 to 2.7 (c. 55%) in 2001 but most trees will probably recover. As with the other stands, dieback decreased as diameter increased. This was a highly significant ($p<0.0001$) trend in the sawtimber aspen type.

Six regeneration plots (1/200 acre) were measured and varied considerably between shady and sunny sites. The mean was 2,917 sprouts per acre with a range of 600 to 6,200 per acre, reflecting more than adequate regeneration. Although it would probably be best to harvest this stand and release the suckers, we decided to leave it in order to study long term rates of tree recovery.

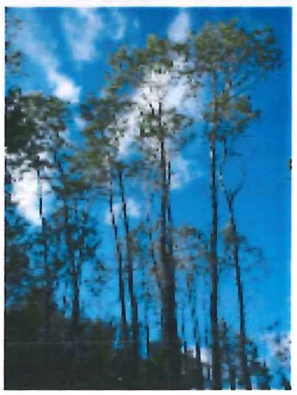


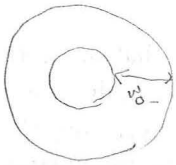
Figure 14. The sawtimber aspen suffered the least damage.

Summary and Follow-up

Although this survey encompasses several stand types and size classes from a wide geographic distribution , the one factor which seems to be significant for all sites is the considerable damage to crowns and leaders with a resulting high amount of crown and leader dieback. The Manitowoc County storm caused the highest outright mortality whereas the stands in Waushara and Douglas counties have suffered mostly dieback and growth loss. With the amount of damage done to tree growth and the subsequent risk of disease and bark beetle attack, tree harvest is probably warranted in all of the surveyed stands. The stands in Manitowoc have already been cut, with the exception of the Wagner pines. The Douglas County stands, with the exception of the sawtimber aspen, are scheduled for harvest in the winter of 2002. This stand and the sapling pine stand in Waushara County will be left in order to monitor the long term effects of hail damage.

Survey work will be continued in 2002 on both the lowland and upland sites in Manitowoc County in order to monitor both canopy tree recovery and regeneration success, in the Waushara pine stand to follow growth rates and increased susceptibility to disease, and in the aspen sawtimber stand in Douglas County to monitor longterm survival of hail damaged aspen.

Annosum Root Rot Biocontrol Stump Treatment Trial
Detailed Procedures



By Mark Guthmiller
Plant Pest and Disease Specialist
Wisconsin Dept. of Natural Resources

Confirming and marking infected stands:

In order to confirm annosum infection centers, detailed ground surveys were conducted in the summer of 2000 and again in the early spring of 2001 on the Sauk County Forest and the River Valley School Forest. Confirmation was based on the presence of fruiting bodies (conks). Infection centers were flagged and located with a GPS. In February, 2001, the trees were marked for a salvage and thinning harvest. A 30 foot buffer of healthy trees around each infection center was marked for harvest . Stumps inside the buffer zone would be treated with *P. gigantea* after harvest. Trees immediately adjacent to the outer buffer (flagged with red tape, see figure) would remain after the harvest and help facilitate the harvesting and stump treatment process. The outer buffer zone was mapped using GPS, and overlain on an aerial photo to assist loggers and treatment applicators. The first ring of barrier trees were painted red on the base (stump). This would allow the infection zone to be monitored in the future after harvest. Based on the location of the 25 infection centers the overlap of the barrier zones created 12 distinct zones. These twelve barrier zones are being monitored to determine the success of stump colonization by *P. gigantea.*

Timber sale and cutting procedures:

A timber sale contract was written by the DNR Sauk County forester and placed out for bids. The sale included the following specific harvesting instructions. Harvest activity would only be conducted from May 1st to June 30th. The logger had to meet with Sauk County Forest staff on site prior to harvesting to review site and procedures. The logger had to contact Sauk County Forest staff two days prior to harvest activity in order to plan for stump treatments. All hauling needed to be done along a designated hauling trail. All orange (healthy) marked trees had to be harvested first, followed by white and blue (fading and dead) marked trees to prevent possible spread of disease throughout the stand. All blue marked trees (dead) and the bottom 12' of white marked trees (faders) had to be cut to a minimum of 8' (preferably 4') sections and left on site. It was also requested that the brush be placed between rows so it wouldn't cover up stumps in order to facilitate treatment application. Prior to leaving the harvest site, logging equipment had to be washed with a 10% bleach solution to prevent spread of disease.

Collection and growing procedures of *Phlebiopsis gigantea*:

In July of 2000, fresh red pine logs were cut and stacked in a pyramid as trap logs to acquire naturally occurring isolates of P. gigantea from the treatment areas. With collaborative assistance from the University of Minnesota, Plant Pathology Department (U of M), isolates were cultured for use as a stump treatment These cultures were then transferred and grown on 1.5% malt yeast agar (MYA) for approximately two weeks to produce abundant numbers of spores. Spores were collected from cultured plates by light scraping and agitation with 10ml deionized water and diluted to approximately 4 x 10^5 spores/ml.

Stump treatment applications:

At the end of each harvest day between approximately 3:00 and 6:00 p.m. all stumps cut that day were treated with "Sporax" or *P. gigantea*. All stumps in the thinning area were treated with "Sporax" (Sodium tetraborate decahydrate). Sporax was applied as a dry powder completely over the stump surface in a thin layer using shaker jars with holes in the lids. Hand held pressure sprayers were used to apply the spore solution of P. gigantea to stumps in the barrier zone using approximately two sprays per stump, which calibrated to approximately 6 ml per stump or approximately $2.4x10^6$ spores per stump. Communications with U of M indicated that spore counts of 1×10^3 should be adequate for stump colonization if site conditions were cool and moist at time of application. Red dye was added to the spore suspension to help indicate which stumps had been treated. This did not work so at the end of each day tree rows were marked with flagging to indicate the next days starting point. Stumps were treated in the first two weeks of June and weather conditions were ideal with cool temperatures and periodic rainfall.

Sanitation and burn procedures:

After the harvest all remaining infected logs were piled in the infection center using a bulldozer to create burn piles. The piles were left through the summer and fall to dry out and then were burned in January 2002. The burn required more work then expected due to recent rains and dirt piled with logs by the bulldozer during the piling process. Recommendations in the future would be to use a skid loader (bobcat) with a grapple hook to pile logs. This would help prevent dirt from accumulating in the burn pile and offer the ability to shake dirt off logs. The use of a gas powered blower helped fan the fire and facilitate a complete burn of the infected piles.

Monitoring procedures:

Stumps were sampled twice (once in mid-July and once in early-September) to re-isolate P. gigantea from treated stumps. One additional sampling is planned in June of 2002 and another possibly the fall of 2002 if recovery is low. Four stumps (one stump in each cardinal direction) in each of 12 barrier zones were sampled for culturing. The first sampling involved chiseling or using a hatchet to retrieve a small 1"-2" piece of wood. Recovery rates were low and size of sample was a concern. A chain saw was used in the second sampling to acquire a larger wedge approximately 3"-4" from the side of the stump.

Preliminary results:

P. gigantea was found at all sites but not in all stumps. The three sample sites averaged 43.47% recovery after 13 weeks. 15 out of 17 tested isolates were determined to be the same strain as the applied biocontrol isolate. The other two tested isolates were identical to each other and possibly from a naturally occurring strain.

	5 weeks	13 weeks
River Valley School Forest 1	6.70	66.67
River Valley School Forest 2	13.30	20.00
Sauk County Forest	5.60	43.75
AVERAGE	**8.53**	**43.47**

2001 Stump Treatment Results*

(% chips w/ P. gigantea)

*Preliminary data summary from Crystal Floyd, University of Minnesota, Plant Pathology Department. Final sampling result data should be available in our 2002 annual report.

Pruning of Oak by Electric Utilities and the Relationship to Overland Spread of Oak Wilt [1]

Jane Cummings Carlson
Forest Pathologist
Forest Health Protection, DNR
Fitchburg WI

INTRODUCTION

Fresh wounds on oak have long been know to act as infection sites for Ceratocystis fagacearm, the fungus causing oak wilt, particularly during the spring and early summer (2,3,4,5,7,8,9,11). The practice of covering wounds with a tree-wound dressing has been documented as reducing the possibility of infection (6,10). Ideally, oak should not be pruned or otherwise wounded during the spring and early summer. A more conservative approach would include prohibiting pruning throughout the growing season. In 1995, a cooperative effort between the Wisconsin Public Service Commission (WPSC), the Wisconsin Utilities Association Rights-of-Way Maintenance Committee and the Wisconsin Department of Natural Resources (DNR) was initiated to develop and evaluate, effective and reasonable pruning guidelines for Wisconsin's electric utilities. The following guidelines were agreed upon:

have oak wilt except for Lincoln County, which was added because oak wilt is at its southern border.

Guidelines for cutting and pruning oak for utilities and right of way maintenance.

URBAN/RESIDENTIAL	RURAL
April 15 - July 1	April 15 - July 1
No pruning or cutting of oak except in emergencies. Pruning paint must be applied as soon as possible to all final cuts made in emergencies. For treatment of stumps, see definition below.	Pruning or cutting of oak may be conducted. Pruning paint must be applied to all final cuts immediately after cutting. For treatment of stumps, see definition below.
July 2 - April 14	July 2 - April 14
No restrictions.	No restrictions.

URBAN/RESIDENTIAL

Urban/residential sites are defined as any site within incorporated village or city boundaries or sites in direct association with permanent and seasonal residences and dwellings. Residential sites include developed lawn areas and other intensively landscaped areas such as business and industrial properties, parks and golf courses. Residential sites include areas where the vegetation is intensively managed and typically involve yard and street trees of high landscape and ornamental value.

RURAL

Rural sites are defined as those sites not having direct association with a permanent or seasonal residence and include sites in areas of agricultural and forest land use. Rural sites are not intensively developed and typically include areas occupied by native vegetation cover types, stocked with naturally occurring plants.

[1] A survey conducted by the Wisconsin Department of Natural Resources and Alliant Energy.

EMERGENCIES

Maintaining necessary levels of safety, service and reliability may require a utility to perform emergency pruning or removal of oaks within the April 15 - July 1 time frame. Some examples of situations where emergency tree pruning and removal may be necessary include:

Storm-related damage to electrical facilities and/or adjacent trees that has caused or could cause a power outage.

Bringing electrical service (usually distribution) into a new residence or business. Moving electric facilities to accommodate roadwork, pipeline or building construction.

Rebuilding or upgrading distribution facilities to reduce problems associated with stray voltage (as outlined in PSC Docket 05-EI-106).

Whenever safety and timing considerations permit, tree paint should be applied to all final cuts made to oak trees from April 15 to July 1.

STUMPS

Stumps are normally treated with an herbicide to prevent sprouting. The effectiveness this practice in discouraging sap-feeding beetles is unknown. Utilities can continue with their routine stump treatments or apply tree paint to stumps until further information becomes available. If no herbicide is applied, tree paint should be applied to stumps, (to the youngest 2 growth rings) immediately after making the final cut. If the tree cut was dead at the time of cutting, no treatment is necessary.

OBJECTIVES

The objective of this work was to determine whether or not the pruning guidelines were effective in preventing overland spread of Ceratocystis fagacearum. Specifically, two time periods and practices are being evaluated:

1. Pruning conducted from April 15 - July 1; wounds treated with a tree wound dressing.
2. Pruning conducted from July 2 - September 15; wounds non treated.

MATERIALS AND METHODS

Alliant Energy, an electric power company, volunteered to participate in this study. Alliant Energy's territory (southern 2/3 of WI) includes vast acres of oak in rural areas. For five years, (1995 - 1999), Alliant Energy provided the following data to the DNR:

- Maps showing locations of where the company pruned oaks
- Dates when pruning was conducted
- Number of oaks pruned
- Species of oak pruned

Each year, the DNR surveyed the areas pruned by Alliant Energy. Trees pruned during the April 15 - July 1 time period were surveyed in July and August of the same year of pruning. Trees pruned during July 2 - September 15 were surveyed in April and May of the year following pruning. The following observations and data were collected during the survey:

- Symptoms of oak wilt on pruned trees, including any wilting of leaves were noted; if symptoms were present, samples (twigs holding wilting leaves) were collected and isolations for C. fagacearum were conducted. Half of the sample was sent to the Wisconsin Department of Agriculture, Trade and Consumer Protection and half of the sample was analyzed by WI DNR forest health protection staff.
- Photographs were taken of symptomatic trees as documentation.

- The distance from the pruned trees to the closest active oak wilt pocket was noted.

If oak wilt was confirmed as being present in pruned trees, a map was drawn that included the infected/pruned trees and trees within approximately 100' of the infected trees. Data were collected on the species of oak, whether or not each tree had been pruned, the health status, diameter and distances between trees. The presence of oak stumps was also noted. If infected/pruned trees were observed, methods developed by Bruhn et. al. (1) were used to determine whether or not pruned/infected trees were likely to be infected via root grafts. Bruhn's method uses soil type, tree diameter and distance between trees to determine the likelihood of root grafting.

RESULTS

April 15 - July 1; 1995 - 1999

Table 1. Number of red-oak-group and white-oak-group trees pruned between April 15 and July 1 1995-1999.

	No. trees pruned		No. Trees Positive for Oak Wilt	
Year	**White oak**	**Red oak**	**White oak**	**Red oak**
1995	90	184	0	3
1996	40	252	0	1
1997	91	198	0	0
1998	58	80	0	1
1999	0	103	0	0
Total	**279**	**817**	**0**	**5**

Of the 817 red-oak-group trees pruned and treated with a wound dressing during the April 15 - July 1 time period, 2 trees pruned in April and 3 pruned in June were confirmed positive for oak wilt. No white oaks pruned during the April 15 - July 1 period showed symptoms of oak wilt.

In each of the 5 confirmed cases, data were collected and maps drawn to determine whether or not root graft spread could have caused the infections. In all 5 cases, evidence was present to confirm the infections were most likely initiated through root-graft spread as opposed to overland spread. Supporting evidence included the following:

- The application of Bruhn's model to each of the trees in question revealed a 95% probability that root-graft spread could have occurred from previously infected trees to the trees in question. (Table 1).
- The presence of stumps, old dead, recently dead and actively wilting trees within root graft distance of the trees in question. These factors depict a typical active oak wilt pocket, expanding through root grafts.
- The presence of many non-symptomatic trees along the lines that received the same pruning and wound treatment as the one wilting tree. In each of the confirmed cases, several red oaks along the line had been pruned and treated, and in each case, only one or two trees were wilting.

Table. 2. Minimum inter-tree distances (based on combined tree diameters and soil type) necessary to declare with 95% confidence, that root graft transmission is not likely to occur between an infected and healthy tree.

	Inter-tree Distance (')			Inter-tree Distance (')	
Combined dbh (")*	Loamy Sand	Sandy	Combined dbh	Loamy Sand	Sandy
2	3.1	3.9	18	27.8	34.9
4	6.2	7.8	20	30.9	38.8
6	9.3	11.6	22	34.0	42.7
8	12.4	15.5	24	37.1	46.6
10	15.4	19.4	26	40.2	50.4
12	18.5	23.3	28	43.2	54.3
14	21.6	27.2	30	46.3	58.2
16	24.7	31.0	32	49.4	62.1

*Combined diameters = diameter of diseased tree at 4.5' from the ground, added to the diameter of the tree in question.

July 2 - September 15; 1995 - 1999

Table 3. Number of red-oak-group (including red, northern pin and black oak) and white-oak-group (including white and bur oak) trees pruned between July 2 and September 15 in 1995 - '99.

	No. trees pruned		**No. Trees Positive for Oak Wilt**	
Year	**White oak**	**Red oak**	**White oak**	**Red oak**
1995	96	553	0	1
1996	121	362	0	0
1997	66	155	NA*	0
1998	NA	166	NA	1
1999	NA	121	NA	0
Total	**283**	**1,357**	**0**	**2**

*Refoliation following tatters masked any symptoms of oak wilt.

Of the 1,357 red-oak-group trees pruned (and not treated with a wound dressing) during the July 2 - September 15 period, 2 pruned in August were confirmed positive for oak wilt. In both of these cases, data regarding distance to actively wilting trees and previously killed trees supported root-graft spread as the likely mode of infection.

None of the 217 white-oak-group trees pruned during the July 2 - September 15 period in 1995 and 1996 had symptoms of oak wilt. In 1997 - '99, a spring phenomenon called "tatters" occurred throughout much of the survey area. Tatters, still under investigation as to its cause, affects white oaks in the spring as buds are expanding. Affected trees broke bud but the leaves had a torn and tattered appearance. Severely affected trees refoliated yet some of the new leaves were quite chlorotic. These symptoms made definitive observations on white oak difficult during the 1998 and 1999 survey. Thus, the data for white oak from 1997, 1998 and 1999 is not valid for this study.

An unresolved issue

Two of the 38 red oaks pruned during September of 1997 were found dead during the spring of 1998 survey; one was observed wilting. The cambium of all three trees was too dry to sample thus the cause of mortality could not be confirmed. One dead tree was located within grafting distance to a recently-dead tree (died within a year of the tree in question). The other dead tree was located within grafting distance of 4 red oak stumps but was not within grafting distance of any actively wilting trees or recently dead trees. Active oak wilt was evident within 500' of the tree in suspect, which is too far for root grafting. The one wilting tree had lost all of its foliage except for a few wilting leaves on epicormic sprouts near the top of the tree. These sprouts were sampled but the presence of C. fagacearum was not confirmed in the laboratory. The cambium of the sprouts was quite dry, thus they were likely to be poor samples. Employees of Alliant Energy were contacted regarding these three unresolved trees and the sites were revisited with one of the right-of-way maintenance workers. After long discussions, we determined that no definitive conclusion could be drawn regarding what killed these three trees and what role the utility may have played in causing the mortality. This experience pointed to the importance of observation and notation of anything unusual by the crews conducting the pruning. Notes as to the health status of the trees in question and their neighbors at the time they were pruned, would have been immensely helpful. An additional survey, conducted during the fall, would also have helped unravel this mystery.

Distance Data

In order to provide DNR with the highest number of oaks possible, Alliant Energy concentrated their pruning in areas where oak was prevalent. These areas also happen to be located where oak wilt is active and in almost every case, within ½ mile of each survey location. In each case of confirmed oak wilt in trees that had been pruned along the power lines, active oak wilt was present either right along the line or just behind it. As stated earlier, this close proximity was always close enough to provide root graft spread. There were no confirmed cases of oak wilt in pruned trees where active oak wilt was located beyond grafting distance. There is no definitive data on the exact distance this disease will spread via vectors.

DISCUSSION AND CONCLUSIONS

After 5 years of surveying oaks along Alliant Energy's distribution lines, 5 of the 817 red-oak-group trees and 0 of the 279 white-oak-group trees all pruned from April 15 - July 1 and treated with a wound dressing were confirmed to be infected with C. fagacearum. In each of the 5 positive cases, root graft transmission from neighboring trees was the most probable method of disease transmission.

Variables such as weather, distance to active oak wilt areas and vector population could all have an influence on the likelihood of infection. A controlled scientific study would attempt to reduce these variables in order to validate results. Unfortunately, the "real-world" survey cannot eliminate these variables and the potential effects they may have had on infection. What this survey does do is determine the number of infections that have occurred in areas where Alliant Energy has pruned and hypothesizes the role root graft spread has contributed versus overland spread. This survey also tests the management recommendations and how effective they may work in the working environment. It is already well known that overland infection occurs most commonly in April, May and June and that applying a wound dressing immediately after wounding during this period will reduce the chances of an overland infection. This data adds supportive evidence to this management strategy. In July of 2001, PSC 113.0511 was established and is provided at the end of this report. PSC 113.0511 now provides the rules related to oak tree cutting and pruning by which electric utilities regulated by the Public Service Commission must follow. This survey did not reveal any need to adjust the rules in PSC113.0511. DNR forest health personnel will continue to respond to calls relating to potential overland spread via utility pruning. If evidence reveals problems with the rules, adjustments will be pursued.

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PSC 113.0511 Oak tree cutting and pruning.

(1) In urban/residential areas: From April 15 through July 1 of each year, no pruning or cutting of oak trees is permitted except in emergencies. Herbicide treatment of stumps to prevent sprouting may substitute for the painting of stumps. If a tree is dead at the time of cutting, no treatment is necessary.

(2) An urban/residential site is any site within incorporated village or city boundaries or any site in direct association with permanent or seasonal residences and dwellings. Residential sites include developed lawn areas and other intensively landscaped areas such as business and industrial properties, parks and golf courses. Residential sites include areas where the vegetation is intensively managed and typically involve yard and street trees of high landscape and ornamental value.

(3) In rural areas: From April 15 through July 1 of each year, pruning paint must be applied to all final cuts on oak trees immediately after cutting. Herbicide treatment of stumps to prevent sprouting may substitute for the painting of stumps. If a tree is dead at the time of cutting, no treatment is necessary.

(4) A rural site is any site not in direct association with a permanent or seasonal residence. Rural sites include sites in areas of agricultural and forest land use. Rural sites are not intensively developed and typically include areas occupied by native vegetation cover types and are stocked with naturally–occurring plants.

(5) Emergency pruning or removal of oaks within the April 15 to July 1 time period is permitted to maintain necessary levels of safety, service and reliability. Some situations where emergency tree pruning and removal may be necessary include:

- **(a)** Storm–related damage to electrical facilities and/or adjacent trees has caused or could cause a power outage.
- **(b)** Bringing electrical service into a new residence or business.
- **(c)** Moving electrical facilities to accommodate road, pipeline, or building construction.
- **(d)** Rebuilding or upgrading distribution facilities.

(6) Counties where oak wilt has not been confirmed are exempted from these oak tree cutting and pruning **restrictions.** The commission shall annually provide the utilities with a list of exempted counties.

History: Cr. Register, July, 2000, No. 535, eff. 8–1–00.